Reviewing the New Growth Literature

NORMAN GEMMELL

The past decade has seen an explosion of interest among economists in the theory of economic growth and has led to a burgeoning 'new growth theory' literature. Traditional neoclassical growth theory offered no role for education in this process, with growth in per capita incomes being determined entirely by 'knowledge accumulation' of unspecified origin. Recent theories have, however, often introduced education explicitly or implicitly as the source of human capital accumulation. This contribution briefly reviews the role of education in these new growth theories and then goes on to examine recent empirical evidence which has sought to shed light on the relationship between education and economic growth.

New growth theory

Human capital is typically introduced in new growth theories either by:

(a) incorporating educated labour *as a factor input*;[1] or
(b) explaining the process of knowledge accumulation by relating it to human capital accumulation either directly or via research and development (R&D) activity.

If human capital can be seen as a factor of production then the rate of its accumulation will directly affect the growth rate. The effects of human capital accumulation on growth are enhanced if there is an externality effect where higher levels of human capital not only increase the skill of the workers concerned but also raise the productivity of others in the economy. Where human capital accumulation is viewed as increasing the stock of knowledge this knowledge is seen as having a public good character: it is assumed to 'spill over' freely to all firms (and sometimes across countries too), enhancing the productivity of the economy as a whole, rather than being created and retained within firms (e.g. by patent protection).

Human capital as a factor input

The two main types of model here are:

(I) where educated labour is used in production but its creation is left unspecified; and
(II) endogenous (two or more sector) growth models in which an education sector produces human capital for use in the production sector(s).

We consider each of these in turn.

First, in type I models, if educated labour is added to the standard neoclassical growth model, it yields a (per capita) income growth equation in which physical capital and human capital investment rates (i.e. as ratios of GDP) determine growth rates. Alternatively, the initial level of human capital can replace the human capital investment rate. An important feature of this model is that, by proposing a role for the human capital investment rate, it provides a link between educational expenditures and growth.

Second, Lucas models human capital in a firm's production function in a manner analogous to type I models (an 'internal'

Norman Gemmell, Department of Economics, University of Nottingham, University Park, Nottingham NG7 2RD, UK.

1356-3467/98/010129-06

effect), but also allows for an 'external effect' whereby the average level of human capital in the economy affects individual firms' outputs (but is ignored in their profit-maximising decisions).[2] Individual workers decide on their time allocation between acquiring education and working in the 'production' sector on the basis of standard (intertemporal) utility maximisation. Lucas assumes that there are constant returns to the firm's inputs of capital and human capital (e.g. doubling both these inputs doubles output), but the additional external effect means that, at the level of the economy as a whole, there are increasing returns to scale. In the Lucas representation, then, even without the external effect, long-run growth is now a function of investment in both physical and human capital, so that there is an important role for education in the long run. Any external effects reinforce this argument.

Models of type I above treat human capital as a 'private good'; that is, education is embodied solely in the individual worker and the skills which education creates are best thought of as 'rival' and 'excludable'. The Lucas approach, however, while maintaining rivalness (use of a worker's education skills in one activity precludes their use in others) allows for some non-excludability—some of the gains from education spill over to others. In the jargon, there are 'educational externalities'.

R&D: human capital in knowledge accumulation

In addition to affecting the quality or productivity of labour inputs in production, education might have a role to play in the accumulation of knowledge. A branch of new growth theory has concentrated on endogenising technical progress, i.e. attempting to explain its rate, and recent contributions have recognised an important role for human capital—knowledge accumulation requires resources to be devoted to research and development activities where 'ideas' can be generated. A characteristic of these models is the public good nature of knowledge. This 'public good' knowledge is naturally associated with the research undertaken in the higher education sector.

Numerous models incorporating R&D activities and the production of 'ideas' have been developed, but those of Paul Romer are among the most prominent. In one recent version he models an endogenous growth process in which growth results directly from physical capital investment which in turn is driven by investment in a research and development sector generating ideas for 'new' designs/goods.[3] These new goods, by being used as intermediates elsewhere in the economy, provide the driving force behind knowledge accumulation. Romer then hypothesises that the creation of these new designs/goods is a function of the stock, as well as the growth, of human capital in the form of 'basic' and 'applied' scientific knowledge acquired via higher education. Thus firms operating in countries with a larger pool (and faster growing pool) of qualified scientists can innovate more readily and therefore enjoy more rapid rates of technical progress and productivity growth.

Recently, Jones has proposed a model including three sectors producing human capital skills (education), new intermediate goods (ideas) and a consumption good.[4] A particular merit of Jones's model is that it incorporates a number of features which appear separately in earlier contributions to this literature. He then demonstrates that whether human capital acquisition has effects on the level or growth rate of income depends on the assumed strength of educational spillovers in different parts of the model, and on whether constant or decreasing returns is assumed. Two important outcomes emerge from this approach. First, the predictions of those models of endogenous knowledge accumulation are highly sensitive to their assumptions relating to the

extent of externalities or factor returns. Second, despite the relatively complex nature of the model, the resulting explanation of income growth rates is very similar to type I models of human capital as a factor input. Both models predict that countries with higher investment rates for both physical and human capital, faster population growth and a higher level of technology will enjoy faster income levels. This 'observational equivalence' implies severe problems for attempts to discriminate empirically between alternative theories. Several theories may be consistent with observed data.

Empirical evidence

In this section we review the empirical evidence on the relationship between education and economic growth rates or income levels. Most evidence comes from cross-section regression analysis on samples of developing and/or OECD countries for various post-1960 periods, though increasingly time-series testing on individual (or groups of) countries is being pursued. There are numerous methodological problems with these studies which suggests that caution is required in interpreting their results.[5]

There is now a reasonably large body of evidence on the relationship between education (or human capital) in general and economic growth, and more limited evidence for particular levels of education.[6] Using labour force educational attainment data, several studies have found that countries with more educated labour forces tend to grow faster, other things equal; other studies have failed to find a significant education–growth relationship. The reasons for this are unclear, but may be related to differences and inaccuracies in the educational datasets. In a review and sensitivity analysis of the determinants of cross-country differences in long-run growth rates Levine and Renelt concluded that education is one of a small number of fairly robust determinants, though the only education variable considered was school enrolment.[7]

The most comprehensive evidence from cross-section regressions comes from Barro and Sala-i-Martin. They find, for male educational attainment, that higher initial secondary and tertiary education have significant positive growth effects and that these are more strongly evident than when years of education are aggregated. Across a wide-ranging sample of countries they find that higher education has especially large effects. A strange finding is that female education appears to be inversely related to growth, though this may be a result of deficiencies in the construction of the educational dataset. Barro and Sala-i-Martin also investigate whether public educational expenditures significantly improve growth performance and confirm a positive role.[8]

Wolff and Gittleman investigate the impact of human capital on labour productivity growth for OECD countries during 1950–88, using both education enrolment and educational attainment data. Their results suggest that findings of a significant positive effect of education on growth are sensitive to the other variables included in their equations. Various educational enrolment and attainment variables fail to reveal significant effects on income growth. They do find, however, that university enrolment rates are positively associated with labour productivity growth and that the number of scientists and engineers per capita is significant across a wide range of specifications.[9]

Gemmell, using a simpler index of labour force education (i.e. numbers of workers who have passed through primary, secondary and tertiary education), investigates the effects of the three levels of education across developing and OECD countries over the 1960–85 period. Splitting his sample by income level he finds that, other things being equal, while primary and secondary skills are important for growth in developing countries, tertiary skills are important for growth in OECD countries. The two features which distinguish the Gemmell studies from most others are the simpler educational attain-

ment indices used, and the inclusion of data on both initial educational levels and the subsequent increase in education levels over the period. Both the initial level and subsequent growth of tertiary education were found to be positively and significantly associated with per capita income growth in OECD countries.[10]

Nehru and Dhareshwar report particularly interesting results. In seeking to explain productivity growth they calculate total factor productivity (TFP) growth indices over 1960–87 for a wide range of countries. Previous studies have used labour productivity indices; yet the various hypotheses considered above regarding human capital effects on 'knowledge accumulation' relate more naturally to TFP than to labour productivity. Using indices of educational attainment (derived from enrolment rates) to explain TFP growth they find a particularly important role for human capital. Their conclusions are worth quoting:

- human capital accumulation is three to four times as important as raw labour in explaining output growth, and its contribution is larger than estimated in previous studies.
- Countries with faster GDP growth rates, most of which are in East Asia, appear to have based their performance more on the speed of factor accumulation than on the pace of TFP growth.
- TFP growth between 1960 and 1987 is strongly associated with the initial level of human capital.[11]

Their second conclusion is interesting, and is confirmed by Young, because it suggests that the rapid growth performances of the East Asian economies (often held up as examples for OECD countries to emulate) are substantially the result of the educational (and other) investments they have made to raise their human capital stocks, rather than the result of acquiring new technologies to make existing factors more productive.[12] In summary, cross-section regression studies of growth have numerous methodological drawbacks and much more testing on better quality educational data, particularly for higher education, is required before firm conclusions can be drawn on the direct effect of education on economic growth. The weight of evidence is increasingly that education is positively associated with income growth, although the robustness of these results, and the direction of causality, are uncertain.

Evidence from the annual time-series of individual (or groups of) countries is potentially more reliable in identifying the sources of countries' growth performances, not least because it avoids questionable assumptions implicit in much cross-country work. In practice, limited numbers of observations often restrict the use of time-series methods (or their sophistication) and, to date, there are few studies of this sort which investigate educational effects on income levels or growth. One of the most interesting is Jenkins, who explores the links between education and economic performance for the UK (1971–92).[13] A useful feature of this study is the use of educational qualifications as a measure of labour skills. Qualifications data represent a better measure of educational output compared with 'input-based' measures such as enrolment rates or years of schooling, and probably capture educational quality dimensions more accurately. Jenkins collapses 14 categories of qualification into three groups: higher education qualifications (including postgraduate and other tertiary qualifications, such as teachers and nurses); intermediate qualifications (school and trade-related qualifications); and no qualifications. Testing the effects of these on an index of total factor productivity, Jenkins finds statistically strong evidence that both intermediate and higher qualifications have substantial effects on

productivity, with the latter appearing roughly to double the productivity of a worker compared with one with no qualifications. Jenkins also found broadly similar evidence for Australia, the USA and Sweden.

Finally, a time-series analysis by Canning *et al.* sheds some light on the education–growth debate. They estimate time-series models for 77 countries, in which output (per worker) levels are explained by physical and human capital (per worker) using 'average years of education' data. Given the diverse countries considered, their estimates for the education parameter are highly volatile and often negative. However, when they restrict their focus to the OECD countries, they find a significant positive effect of years of education on income levels.[14]

Conclusions

New growth theories have provided more rigorous intellectual backing than hitherto available to those who claim that an economy's growth rate over the long run can be enhanced by devoting more resources to education. A number of plausible ways in which education might make an impact on the income growth process have been proposed in the last decade and an empirical literature is emerging which seeks to identify, at the aggregate level, whether these education–income growth links exist. It is rather early to draw definite conclusions, but the weight of evidence is towards accepting that, other things being equal, countries with more educated labour have tended to grow faster over the post-1960 period.

Drawing policy conclusions from this is, however, extremely hazardous. It remains unclear which types or levels of education are most important and whether this differs across countries. Most studies have also been unconcerned with the relative importance for growth of education compared with other determinants such as investment in physical capital. For example, it is generally not possible to say whether the marginal pound should be taken in tax and spent on education or public capital investment, or left for the private sector to invest. Differences in educational quality have typically been ignored in the new growth literature so that it does not allow us to identify whether resources should be devoted to expanding numbers of pupils/students, or to expanding the quality or quantity of education for existing pupils/students. Much further research in these areas remains to be done. Nevertheless, establishing that education and long-run economic growth rates are related is a prerequisite for much of the policy debate surrounding the allocation of resources to public, or indeed private, education.

Notes

1. N. Mankiw, D. Romer & D. Weil, 'A Contribution to the Empirics of Economic Growth', *Quarterly Journal of Economics*, Vol. 107 (1992), pp. 407–37; and David Romer, *Advanced Macroeconomics* (McGraw-Hill, 1996).
2. Robert Lucas, 'On the Mechanics of Economic Development', *Journal of Monetary Economics*, Vol. 22 (1988), pp. 3–42; Paul Romer, 'Increasing Returns and Long-run Growth', *Journal of Political Economy*, Vol. 94 (1986), pp. 1002–37; and Paul Romer, 'Endogenous Technical Change', *Journal of Political Economy*, Vol. 98 (1990), S71–S102.
3. Paul Romer, 'Human Capital and Growth: Theory and Evidence', *Carnegie–Rochester Conference Series on Public Policy*, No. 32 (1990), pp. 251–86. See also his 'Idea Gaps and Object Gaps in Economic Development', *Journal of Monetary Economics*, Vol. 32 (1993), pp. 543–73 and the references cited in note 2.
4. C. I. Jones, 'Human capital, ideas and economic growth', unpublished paper presented to the VIIIth Villa Mondragone International Economic Seminar on Finance, Research, Education and Growth, Rome, Italy, June 1996.
5. Norman Gemmell, 'Externalities to higher education: a review of the new growth literature', Report 9 in: The National Committee of Inquiry into Higher Education, *Higher Education in the Learning Society*, Reports 5–9, 1997, pp. 109–49.
6. Robert Barro, 'Economic Growth in a Cross-section of Countries', *Quarterly Journal of Economics*, No. 106 (1991), pp. 407–43; Robert Barro & Jong-Wha Lee, 'International Comparisons of

Educational Attainment', *Journal of Monetary Economics*, Vol. 32 (1993), pp. 363–94; Robert Barro & Jong-Wha Lee, 'Losers and Winners in Economic Growth', *Proceedings of the World Bank Annual Conference on Development Economics*, 1993, pp. 267–97; Robert Barro & Jong-Wha Lee, 'Sources of Economic Growth', *Carnegie-Rochester Conference Series on Public Policy*, No. 40 (1994), pp. 1–46; V. Nehru & A. Dhareshwar, *New Estimates of Total Factor Productivity Growth for Developing and Industrial Countries*, Policy Research Working Paper 1313, World Bank, Washington D.C., 1994; and N. Oulton & G. Young, *The Social Rate of Return to Investment*, National Institute of Economic and Social Research Discussion Paper No. 93, London, 1996.

7. R. Levine & D. Renelt, 'A Sensitivity Analysis of Cross-country Growth Regressions', *American Economic Review*, Vol. 82 (1992), pp. 942–63.
8. Robert Barro & Xavier Sala-i-Martin, *Economic Growth* (McGraw-Hill, 1995).
9. E. Wolff & M. Gittleman, 'The role of education in productivity convergence: does higher education matter?', in: A. Szirmai, B. van Ark & D. Pilat (Eds), *Explaining Economic Growth* (North–Holland, 1993).
10. Norman Gemmell, 'Endogenous Growth, the Solow Model and Human Capital', *Economics of Planning*, Vol. 28 (1995), pp. 169–83; and Norman Gemmell, 'Evaluating the Impacts of Human Capital Stocks and Accumulation on Economic Growth: Some New Evidence', *Oxford Bulletin of Economics and Statistics*, Vol. 58 (1996), pp. 9–28.
11. Nehru & Dhareshwar, *New Estimates*, pp. 26–7.
12. A. Young, 'A tale of two cities: factor accumulation and technical change in Hong Kong and Singapore, in: *NBER Macroeconomics Annual 1992*, pp. 13–54; and A. Young, 'The Tyranny of Numbers: Confronting the Statistical Realities of the East Asian Growth Experience', *Quarterly Journal of Economics*, Vol. 110 (1995), pp. 641–80.
13. H. Jenkins, *Education and Production in the United Kingdom*, Economics Discussion Paper No. 101, Nuffield College, Oxford, 1995; and H. Jenkins, *Infrastructure, Education and Productivity: A Multi-Country Study*, unpublished D.Phil. thesis, Nuffield College, Oxford, 1995.
14. D. Canning, P. Dunne & M. Moore, 'Testing the augmented Solow and endogenous growth models', mimeo, Queen's University of Belfast, 1995.

Securing Commitment to Skill Formation Policies

FRANCIS GREEN

Improvements in education and training systems have become the focus of a cosy coalition of interested parties in modern economies. Governments parade education and training policies as the means to promote economic growth and employers' groups see them as supporting 'competitiveness'. Skill formation policies are even argued to be the one remaining avenue for discretionary state intervention in globally integrated industrialised economies. Meanwhile, pupils, parents and students want opportunities for personal advancement and workers in the skill formation industries are pleased to bask in the light of social importance.

Sceptical voices abound, however, among which I count my own. Doubt concerns not the efficacy of skill formation policies, but the presumption that there is one 'optimal' forward route for advanced capitalist economies. Rather, it is more accurate to consider a range of routes to capital accumulation, sometimes caricatured by a dualism of the 'high road' and the 'low road'. Along the 'high road', the

Francis Green, Leeds University Business School, University of Leeds, Leeds LS2 9JT, UK.

1356-3467/98/010134-05